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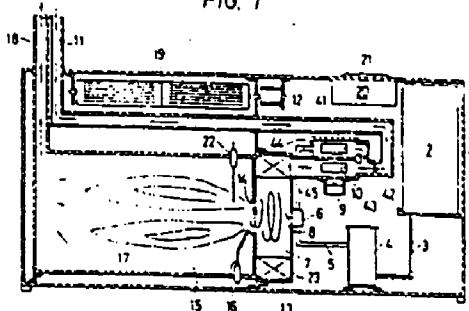
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㉗ Electric liquid atomizing apparatus.

㉘ An apparatus for atomizing a large quantity of liquid such as water, liquid fuels, lotions or the like comprises an atomizer including a body having a pressurization cavity for containing a liquid, a nozzle base mounted on the body and having a plurality of orifices communicating with the pressurization cavity, an electric vibrator mounted on the body, and an electric circuit means for applying an alternating voltage to the electric vibrator to vibrate the latter back and forth, for thereby expelling a large quantity of liquid droplets of small and uniform diameter successively out of the orifices.

FIG. 1



1                    TITLE OF THE INVENTION

2                    ELECTRIC LIQUID ATOMIZING APPARATUS

3  
4                    BACKGROUND OF THE INVENTION

5        Field of the Invention:

6                    The present invention relates to an apparatus for  
7        atomizing large quantities of liquid such as liquid fuels,  
8        water, lotions or the like.

9        Prior Art:

10                   A variety of liquid atomizers have heretofore been  
11        proposed and practiced in the art. One such known atomizer  
12        utilizes a pump for ejecting a liquid under pressure through  
13        a nozzle. According to another conventional atomizing appara-  
14        tus , liquid droplets are allowed to fall onto a rotating body  
15        and caused upon hitting the latter to be atomized under centrif-  
16        ugal forces. These prior systems, however, require a high-  
17        pressure pump or a high-speed motor, are large in size and  
18        costly to construct, and cannot achieve a satisfactory degree  
19        of liquid atomization. There are also known ultrasonic  
20        atomizers which incorporate an ultrasonic vibrator for breaking  
21        up the liquid into small droplets. One form of such ultrasonic  
22        atomizer includes a horn vibrator for amplifying the vibrations  
23        from an ultrasonic vibrator up to a level large enough to atomize  
24        the liquid supplied to a distal end of the horn. This ultrasonic  
25        vibrator is disadvantageous in that the vibration amplifying  
26        horn is complex in structure, difficult to machine, expensive  
27        to manufacture, and fails to produce liquid droplets of satisfac-  
28        tory diameter. The vibrator necessitates a liquid supplying

1 device such as a pump, and hence is large-sized and cannot  
2 be built inexpensively. Another known ultrasonic atomizer  
3 comprises an ultrasonic vibrator mounted on the bottom of a  
4 liquid container for directly transmitting ultrasonic energy  
5 into the liquid to atomize the latter with the ultrasonic  
6 energy that reaches the surface of the liquid in the container.  
7 Although the ultrasonic atomizing apparatus for direct ultra-  
8 sonic liquid atomization needs no liquid supplying unit such  
9 as a pump and atomizes the liquid into desired droplets, the  
10 atomizer consumes a great amount of electric energy for atom-  
11 ization and produces ultrasonic vibrations at quite a high  
12 frequency which ranges from 1 MHz to 2 MHz. Such high-  
13 frequency ultrasonic vibrations have an increased level of  
14 undesirable radiation which has a great potential for causing  
15 disturbance in radio waves to be received by television and  
16 radio receivers. Therefore, the atomizer is required to be  
17 equipped with a vibrator driving circuit and a noise prevention  
18 means, and hence is costly to construct.

19 U.S. Patent NO. 3,683,212 to Zoltan, patented August  
20 2, 1972, discloses a system for ejecting a train of small  
21 droplets of liquid through a single orifice in response to  
22 pressure increases due to changes in volume of a piezoelectric  
23 element to which electric command pulses are applied. The  
24 disclosed system can produce a succession of droplets of uni-  
25 form diameter and is suitable for use in ink jet printers and  
26 recorders. The prior droplet ejecting system, however, cannot  
27 be used in a liquid fuel burner or a humidifier which atomizes

1 a large amount of liquid, at a rate of 1 to 20 cc/min.,  
2 into small uniform droplets. More specifically, when the  
3 voltage of supplied pulses is increased in order to produce  
4 droplets in large quantities, the liquid is broken up into  
5 droplets of large diameter. Application of pulses at a higher  
6 frequency makes it impossible to eject liquid droplets out  
7 of the orifice. The system of Zoltan therefore fails to form  
8 droplets of small and uniform diameter in large quantities.

9 In U.S. Patent NO. 3,747,120 to Stemme, patented July  
10 17, 1973, an apparatus for ejecting a succession of small  
11 droplets is effective for use in recording devices such as  
12 an ink jet printer, but is unable to generate large quan-  
13 tities of atomized liquid as small uniform droplets. The  
14 disclosed droplet generator comprises a plurality of super-  
15 imposed plates having small-diameter channels held in coaxial  
16 alignment, a structure which is quite difficult to assemble.

17 Experiments conducted by the present inventors indicated  
18 that the system as shown in U.S. Patent NO. 3,747,120 produced  
19 liquid droplets at a rate of about 0.5 cc/min. even when the  
20 droplets are of an excessively large diameter, and ejected  
21 liquid droplets of smaller diameter at an approximate rate  
22 of about 0.1 to 0.2 cc/min. Thus, Zoltan's system has ex-  
23 perimentally been proven to fail to eject a large quantity of  
24 liquid droplets of small and uniform diameter.

#### 25 SUMMARY OF THE INVENTION

26 In accordance with the present invention, an atomizer  
27 includes a nozzle base having a plurality of orifices defined

1     therein and attached to a body of the atomizer, the orifices  
2     communicating with a pressurization cavity in the body. An  
3     electric vibrator comprising a vibration plate and a plate  
4     of piezoelectric ceramics bonded to the vibration plate is  
5     mounted on the body, the electric vibrator is responsive  
6     to an alternating voltage applied thereacross for vibratory  
7     movement to expel the liquid as fine uniform droplets out of  
8     the cavity through the orifices. An electric control circuit  
9     is connected to the electric vibrator for applying the alter-  
10    nating voltage thereacross to displace the vibrator back and  
11    forth periodically for successive ejection of the liquid  
12    droplets. The electric control circuit includes a means for  
13    changing the alternating voltage in order to produce liquid  
14    droplets controllably in a variety of quantities.

15            It is an object of the present invention to provide  
16    an atomizing apparatus for producing a large quantity of fine  
17    and uniform droplets of liquid.

18            Another object of the present invention is to provide  
19    a liquid atomizing apparatus which is relatively simple in  
20    structure, reliable in operation, small in size, and inexpen-  
21    sive to manufacture.

22            Still another object of the present invention is to  
23    provide an atomizing apparatus including means for producing  
24    atomized liquid in a variety of controlled quantities.

25            Still another object of the present invention is to  
26    provide an atomizing apparatus which will consume a relatively  
27    small amount of energy for liquid atomization.

1       The above and other objects, features and advantages  
2       of the present invention will become more apparent from the  
3       following description when taken in conjunction with the  
4       accompanying drawings in which some preferred embodiments  
5       of the present invention are shown by way of illustrative  
6       example.

7                   BRIEF DESCRIPTION OF THE DRAWINGS

8       FIG. 1 is a longitudinal cross-sectional view of a  
9       liquid-fuel burner which incorporates an electric liquid  
10      atomizing apparatus according to the present invention;

11      FIG. 2 is an enlarged cross-sectional view of an atom-  
12      izer of the present invention;

13      FIG. 3 is an enlarged plan view of a nozzle base in  
14      the atomizer shown in FIG. 2;

15      FIG. 4 is an enlarged diametrical cross-sectional view  
16      of the nozzle base illustrated in FIG. 3;

17      FIG. 5 is an enlarged diametrical cross-sectional view  
18      of a modified nozzle base;

19      FIG. 6 is a circuit diagram of a voltage generator for  
20      applying an alternating voltage to an electric vibrator in  
21      the atomizer;

22      FIG. 7 is a diagram illustrative of waveforms of three  
23      alternating-voltage signals for driving the electric vibrator  
24      at maximum, medium, and minimum power requirements;

25      FIG. 8 is an enlarged fragmentary cross-sectional view  
26      of the atomizer as it is in a droplet-expelling mode of oper-  
27      ation with the electric vibrator bent in one direction;

1        FIG. 9 is a view similar to FIG. 7, showing the  
2        atomizer as it is in a liquid-supplying mode of operation  
3        with the electric vibrator displaced in the opposite  
4        direction;

5        FIG. 10 is a cross-sectional view of an atomizer  
6        according to another embodiment;

7        FIG. 11 is a cross-sectional view of an atomizer  
8        according to still another embodiment;

9        FIG. 12 is a cross-sectional view of an atomizer in  
10       accordance with still another embodiment; and

11       FIG. 13 is a cross-sectional view of an atomizer in  
12       accordance with still another embodiment.

13       DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

14       As illustrated in FIG. 1, a liquid-fuel burner com-  
15       prises a casing 1, a fuel tank 2 housed in the casing 1, a  
16       fuel leveller 4 mounted in the casing 1 and connected to the  
17       fuel tank 2 by a pipe 3 for being supplied with a liquid fuel  
18       from the tank 2, and an atomizer 6 disposed in the casing 1  
19       and connected to the fuel leveller 4 by a pipe 5 through which  
20       the liquid fuel can be delivered from the fuel leveller 4 to  
21       the atomizer 6. The atomizer 6 atomizes the supplied liquid  
22       fuel and ejects fuel droplets 8 thus atomized into a mixing  
23       chamber located adjacent to the atomizer 6.

24       Air is introduced by an air delivering system com-  
25       prising an air charging fan 10 which is driven by a motor 9  
26       through an air delivery pipe 11. The fan 10 supplies draft  
27       to an air rotator or swirling device 13 for supplying a swirling

1 stream of air into the mixing chamber 7, in which air is  
2 mixed with the fuel droplets 8. The fuel-air mixture as it  
3 swirls is discharged through a discharge port 14 into a  
4 combustion chamber 15. The mixture is then ignited by an  
5 ignition means 16, producing flames 17. An exhaust gas is  
6 discharged from the combustion chamber 15 through an exhaust  
7 pipe 18 that extends out of the casing 1. The heat energy  
8 generated by the combustion in the combustion chamber 15 is  
9 transferred to air forced by a fan 19 to move around the  
10 combustion chamber 15, the heated air being dischargable  
11 into a room in which the liquid-fuel burner is installed.  
12 Thus, the liquid-fuel burner serves as a heater for discharging  
13 hot air.

14 The liquid-fuel burner is equipped with a controller  
15 20 for controlling operation of the burner, i.e., operation  
16 of the fans 10, 19, the atomizer 6, the ignition means 16 and  
17 other components in response to command signals from a con-  
18 trol panel 21, and signals from a frame condition detector 22  
19 and a room temperature detector (not shown).

20 As illustrated in FIG. 2, the atomizer 6 comprises a  
21 body 24 having a first pressurization cavity 25 which is in  
22 the shape of an exponential horn. The pressurization cavity  
23 25 has a cylindrical front end portion 26 having an inside  
24 diameter of 3 mm on which there is mounted a circular nozzle  
25 base 27 peripherally sealed by a gasket 28 and held in position  
26 by a holder plate 29 that is fastened to the body 24 by screws  
27 30. The nozzle base 27 includes a central curved or parti-  
28 spherical portion or nozzle 31 having a plurality (thirty seven



1 as illustrated in FIG. 3) of orifices 32 that are arranged  
2 in rows and spaced at equal intervals or equidistantly  
3 from adjacent ones. Each of the orifices 32 is horn-shaped  
4 or conically tapered as shown in FIG. 4 such that an outlet  
5 end thereof on the convex side is smaller in cross-sectional  
6 area than an inlet end thereof on the concave side. The  
7 outlet end of each orifice 32 has a diameter of 80  $\mu\text{m}$  and  
8 the inlet end thereof has a diameter of about 90 to 100  $\mu\text{m}$ .  
9 A modified nozzle base 27 illustrated in FIG. 5 comprises a  
10 curved portion 31 having therein a plurality of orifices 32  
11 each in the form of a combined bowl and aperture.

12 The nozzle base 27 is made from a plate of stainless steel  
13 having a thickness of 50  $\mu\text{m}$  by first defining the orifices  
14 32 in the plate through a one-sided etching process, and  
15 then embossing the central curved portion 31. With the one-  
16 sided etching process, the horn-shaped orifices 32 can be formed  
17 with utmost ease and relatively inexpensively.

18 In FIG. 2, a circular electric vibrator 35 is mounted  
19 in the cavity 25 at a rear end portion thereof, the electric  
20 vibrator 35 comprising a vibration plate 33 of metal and a  
21 plate 34 of piezoelectric ceramics bonded to the vibration  
22 plate 33, the vibration plate 33 being integral with a support  
23 36 attached to the atomizer body 24. The body 24 and the  
24 support 36 jointly define a second cavity 37 therebetween which  
25 is held in fluid communication with the first cavity 25 through  
26 a passage 38 extending circumferentially all around the electric  
27 vibrator 35.

1           The pipe 5 is connected to a lower end of the body  
2   24 in communication with the second cavity 37 through a  
3   fuel filling channel 46 in the body 24. The fuel leveller .  
4   4 controls the level of the liquid fuel to be maintained at  
5   the position A (FIG. 2) in the pipe 5 just below the atomizer  
6   6. The atomizer body 24 is secured by screws 39 to a wall  
7   23 of the mixing chamber 15 with the orifices 32 opening into  
8   the mixing chamber 15. The body 24 is connected at an upper  
9   end thereof to an air suction pipe 45 coupled to a connector  
10  pipe 43 (FIG. 2) disposed upstream of the fan 10 through an  
11  air suction fan 41 housed in an air suction chamber 44 and  
12  coaxially connected to the fan 10 for corotation. The air  
13  delivery pipe 12 is coupled through an orifice or restrictor  
14  42 to the connector pipe 43. The air suction pipe 45 is held  
15  in fluid communication with the second chamber 37 through an  
16  air exhausting channel 40 in the body 24. When liquid fuel  
17  is supplied through the fuel filling channel 46 into the first  
18  and second cavities 25, 37, air is forced out of these cavities  
19  25, 37 through the air exhausting channel 40 into the air suc-  
20  tion pipe 45, while preventing the liquid fuel as supplied from  
21  leaking out through the orifices 32.

22           Operation of the liquid atomizing apparatus thus con-  
23  structed will now be described with reference to FIGS. 1, 2,  
24  6, 7 and 8.

25           In FIG. 1, when the motor 9 is energized under the  
26  control of the controller 20, the air charging fan 10 and the  
27  air suction fan 41 are caused to corotate, whereupon there is

1 developed a negative pressure of about 2 to 3 mm Ag in the  
2 connector pipe 43 due to the orifice 42. The air suction  
3 fan 41 also develops a negative pressure of about 5 to 10 mm  
4 Ag in the air suction chamber 44 and hence in the air suction  
5 pipe 45. Since the orifices 32 are extremely small in dia-  
6 meter, the amount of air introduced therethrough into the  
7 first cavity 25 is also extremely small. The fuel level is  
8 now raised from the position A to the position B as shown in  
9 FIG. 2, whereupon the first and second cavities 25, 37 are  
10 filled up with the liquid fuel supplied. Thus, the air suc-  
11 tion fan 41, the air suction chamber 44 and the air suction  
12 pipe 45 jointly serve as a fuel filling system.

13 The controller 20 includes a means for generating an  
14 alternating voltages to be applied to the electric vibrator  
15 35. The means for generating alternating voltages is illus-  
16 trated in FIG. 6, and waveforms of generated alternating  
17 voltages are shown in FIG. 7 at (a), (b), and (c). The  
18 alternating-voltage generating means comprises an amplifying  
19 output circuit including transistors 47, 48 and 49, capacitors  
20 50, 51, resistors 52, 53, 54 and 55, and an output transformer  
21 56, a Wien bridge oscillator circuit including an operational  
22 amplifier 57, a diode 58, capacitors 59, 60, and 61, and  
23 resistors 62, 63, 64, 65, 66, 67, and 68, a switching circuit  
24 including an N-CH FET (N-channel field effect transistor) 69,  
25 a resistor 70, and a transistor 71, and a duty-cycle controlling  
26 circuit including transistors 72, 73, capacitors 74, 75, resisters  
27 76, 77, 78, 79 and 80, variable resistors 81, 82, and a switch 83.

1 The variable resistors 81, 82 and the switch 83 are ganged  
2 together by a control 84 such that when the control 84 is  
3 actuated in one direction, the resistance of the variable  
4 resistor 81 is reduced, the resistance of the variable  
5 resistor 82 is increased, and the switch 83 will be closed  
6 when the control 84 reaches the end of the stroke in said  
7 one direction. The N-CH FET 69, therefore, has a duty cycle  
8 D which is rendered continuously variable by the control 84  
9 at a constant frequency within the following range:

10 
$$\text{Minimum value} \leq D \leq 1$$

11 The oscillator circuit can supply the amplifying out-  
12 put circuit with various sine-wave voltage signals, as shown  
13 in FIG. 7 at (a), (b) and (c), adjustable by the control 84.  
14 An output alternating voltage applied through output terminals  
15 85, 86 across the electric vibrator 35 is variable accordingly  
16 and can have waveforms as illustrated in FIG. 7 at (a), (b)  
17 and (c). The average power fed to the electric vibrator 35  
18 can easily and reliably be controlled by the control 84. Thus,  
19 the variable resistors 81, 82 and the switch 83 jointly consti-  
20 tute a means for adjusting the quantity of fuel droplets ejected  
21 by controlling the average power supplied to the electric vibra-  
22 tor 35. The controller 20 also includes a dc power supply 87  
23 for supplying a dc power to the circuits therein.

24 Application of the alternating voltage across the  
25 electric vibrator 35 causes the latter to vibrate, enabling  
26 the atomizer 6 to atomize the liquid fuel into fine droplets.

27 When the sine-wave voltage shown in FIG. 7 at (a), (b),  
28 or (c) is applied during its positive half cycle to the electric  
29 vibrator 35, the latter bends toward the first cavity 25 as

1 shown in FIG. 8 causing a pressure increase in the first  
2 cavity 25. The pressure buildup is progressively greater  
3 toward the nozzle base 27 due to the horn-shaped cavity 25.  
4 The liquid fuel is then expelled out of the first cavity 25  
5 through the orifices 32 as small and uniform droplets 8  
6 having a diameter on the order of 50  $\mu$ m. While in the  
7 embodiment illustrated in FIG. 2 the first cavity 25 is  
8 horn-shaped, it may be of other shapes since ejection of  
9 fuel droplets is primarily dependent in principle on  
10 changes in volume of the first cavity which are caused by  
11 displacement of the electric vibrator 35. Furthermore, the  
12 electric vibrator 35 may be shaped and positioned differently  
13 from the foregoing embodiment provided it can cause volume  
14 changes in the first cavity to propel fuel droplets through  
15 the orifices 32.

16 Application of the alternating voltage during the  
17 negative half cycle enables the electric vibrator 35 to bend  
18 away from the nozzle base 27 as illustrated in FIG. 9, where-  
19 upon a negative pressure is developed in the first cavity 25  
20 adjacent to the electric vibrator 35, replacing the expelled  
21 liquid fuel with an additional amount of liquid fuel that is  
22 supplied in the directions of arrows (FIG. 9) through the  
23 passage 38. At this time, the liquid fuel is prevented from  
24 flowing out of the orifices 32 due to the surface tension of  
25 the liquid at the orifices 32. With the passage 38 extending  
26 circumferentially around the circular electric vibrator 35,  
27 the liquid fuel can smoothly and uniformly be supplied from  
28 the second cavity 37 into the first cavity 25. Static pres-  
29 sure on the liquid fuel in the first cavity 25 becomes negative

1 enough to prevent introduction of air through the orifices  
2 32 into the first cavity 25. The second cavity 37 reduces  
3 resistance to the flow of liquid into the first cavity 25,  
4 an arrangement which also assists in smooth and balanced  
5 supply of the fuel into the first cavity 25 and prevention  
6 of air flow back into the first cavity 25 under the negative  
7 pressure buildup therein.

8 The electric vibrator 35 can be bent or displaced  
9 back and forth repeatedly in response to application there-  
10 across of one of alternating voltages, the waveforms of which  
11 are shown in FIG. 7 at (a), (b), and (c), to eject liquid  
12 droplets 8 of a very small and uniform diameter in a controlled  
13 quantity which ranges from 1 cc/min. to 20 cc/min.

14 There would be a danger for the nozzle base 27 to vibrate  
15 under the influence of pressures produced by the electric vi-  
16 brator 35, causing influx of air into the first cavity 25  
17 through the orifices 32. Presence of such air in the first  
18 cavity 25 reduces the pressure buildup caused by the electric  
19 vibrator 35 to an extent which is sufficient to prevent smooth  
20 and reliable ejection of fuel droplets 8 through the orifices  
21 32.

22 Such a danger or difficulty however is completely eli-  
23 minated by the curved nozzle portion 31 of the nozzle base  
24 27, which gives the latter an increased degree of rigidity  
25 making the nozzle base 27 resistant to vibrations. The curved  
26 or parti-spherical nozzle portion 31 can disperse fuel droplets  
27 8 in different directions in a wide conical space in which the

1 droplets 8 are prevented from being re-united into larger  
2 droplets, and hence are available of a uniform diameter.  
3 The small uniform fuel droplets 8 can easily be mixed with  
4 air which is introduced in a swirling motion to help carry  
5 away the droplets 8 into the combustion chamber 15 or to  
6 produce the fuel-air mixture.

7 With the horn-shaped or conical orifices 32, the liquid  
8 fuel is subjected to an increased pressure in the orifices  
9 32 while being expelled therethrough under the pressure build-  
10 up developed by the electric vibrator 35, and can be accelerated  
11 at the outlets of the orifices 32 up to a speed great enough  
12 to overcome the surface tension of the liquid fuel at the  
13 orifice outlets. The horn-shaped orifices 32 also assist the  
14 liquid fuel in the first cavity 25 in separating from the  
15 ejected droplets 8 when the electric vibrator 35 is deflected  
16 away from the nozzle base 27, as shown in FIG. 9.

17 FIG. 10 shows an atomizer according to another embodi-  
18 ment of the present invention. The atomizer comprises a  
19 nozzle base 27 bonded to a body 24, and an electric vibrator  
20 35 located remotely from the nozzle base 27 and outwardly of  
21 a cavity 25 in the body 24.

22 According to another embodiment illustrated in FIG. 11,  
23 an electric vibrator 35 is in the form of a hollow cylinder  
24 disposed around a cavity 25.

25 An atomizer in accordance with still another embodi-  
26 ment shown in FIG. 12 includes a flat nozzle base 27 integral  
27 with a body 24 of the atomizer.

1           As illustrated in FIG. 13, an atomizer according to  
2 still another embodiment has an annular or doughnut-shaped  
3 second cavity 37 defined in a body 24 in surrounding relation  
4 to a first cavity 25, the first and second cavities 25, 37  
5 being held in fluid communication with each other by four  
6 passages 38 (two shown) positioned near the outer periphery  
7 of an electric vibrator 35 and angularly spaced 90 degrees  
8 from adjacent passages 38. The passages 38 are spaced  
9 equidistantly from the axial center of the electric vibrator  
10 35 and hence the first cavity 25 for smooth and equally  
11 distributed supply of liquid fuel from the second cavity 37  
12 into the first cavity 25.

13           Advantages accruing from the arrangement of the present  
14 invention are as follows: No separate liquid supply unit or  
15 pump is required as the atomizer is of the self-priming type  
16 for automatically replacing discharged droplets in the first  
17 cavity 25 through the liquid filling channel 46. Therefore,  
18 the atomizing apparatus is relatively simple in structure,  
19 small in size, and inexpensive to construct. The nozzle base  
20 27 has a plurality of orifices 32 for ejecting therethrough  
21 fine and uniform liquid droplets in large quantities in re-  
22 sponse to a pressure increase in the cavity 25 caused by the  
23 electric vibrator 35. The air exhausting channel 40 allows  
24 air to be discharged out of the cavities 25, 37 when liquid  
25 fuel is introduced through the liquid filling channel 46.  
26 No liquid fuel is caused to flow out through the orifices 32  
27 at the time of charging the cavity 25 with the liquid fuel.  
28 The curved portion 31 serves as a stiffener for the nozzle



1 base 27 for protection against vibration of the latter during  
2 operation of the atomizer 6. Accordingly, influx of air into  
3 the cavity 25 through the orifices 32 is prevented for stabi-  
4 lized liquid atomization. The electric vibrator 35 consumes  
5 a small amount of electric power since it requires only a  
6 vibratory energy to be applied to the liquid which fills the  
7 cavity 25. The atomizing apparatus also has a relatively  
8 small power requirement and produces a reduced amount of  
9 noise or unnecessary energy radiation. The quantity of liquid  
10 droplets expelled can easily be adjusted by controlling the  
11 average power with which the electric vibrator 35 is energized.  
12 The horn-shaped orifices 32 can easily be formed using the one-  
13 sided etching process. The orifices 32 thus shaped are conduc-  
14 tive to generation of small and uniform liquid droplets. The  
15 second cavity 37 and the symmetrically defined passage 38  
16 permit liquid to be introduced smoothly into the first cavity  
17 25 without developing an excess negative pressure in the latter,  
18 a structure which assures stable liquid atomization. The air  
19 delivery system and the fuel filling system are coupled with  
20 each other for joint operation. This structure serves as a  
21 fail-safe device to prevent an atomization process from being  
22 started while the air delivery system is not operating. With  
23 the air delivery system and fuel filling system thus combined,  
24 the atomizing apparatus is simpler in structure and less  
25 costly to manufacture. The fuel filling system is operated  
26 under air pressure and hence is relatively simple and inexpen-  
sive.

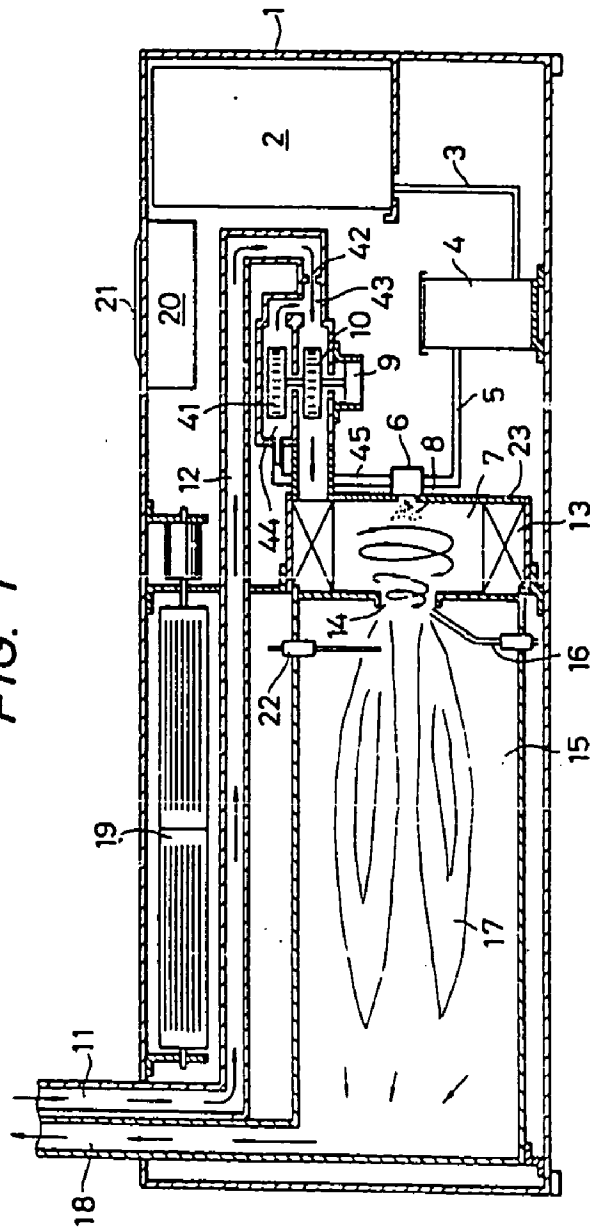
1           Although various preferred embodiments have been  
2 shown and described in detail, it should be understood that  
3 many changes and modifications may be made therein without  
4 departing from the scope of the appended claims.

CLAIMS

1. An atomizing apparatus comprising:
    - (a) a body having a cavity for containing a liquid therein;
    - (b) a nozzle base mounted on said body and having a plurality of orifices defined therein and communicating with said cavity;
    - (c) an electric vibrator mounted on said body and movable to pressurize the liquid in said cavity for ejecting a quantity of the liquid as atomized droplets through said orifices; and
    - (d) electric means for applying an alternating voltage to said electric vibrator to displace the latter back and forth periodically, whereby said atomized droplets can be expelled successively out of said orifices.
  2. An atomizing apparatus according to claim 1, said body including an liquid filling channel for supplying there-through the liquid into said cavity, and an air exhausting channel for discharging therethrough air from said cavity.
  3. An atomizing apparatus according to claim 1 or 2, said nozzle base including a curved portion, said orifices being defined in said curved portion.
  4. An atomizing apparatus according to claim 1, 2 or 3, said electric means including means for adjusting the quantity of droplets ejected by controlling an average power supplied to said electric vibrator.
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FIG. 1



5. An atomizing apparatus according to any of claims 1 to 4, each of said orifices being in the shape of a horn, and having an inlet opening into said cavity and an outlet opening away from said cavity, said inlet being larger in cross-sectional area than said outlet.
6. An atomizing apparatus according to any of claims 1 to 5, said orifices being formed in said nozzle by a one-sided etching process.
7. An atomizing apparatus according to any of claims 1 to 6, said body including a second cavity for supplying the liquid to said first-mentioned cavity, and a passage by which said first-mentioned cavity and said second cavity are held in fluid communication with each other.
8. An atomizing apparatus according to claim 7, said passage being disposed adjacent to said electrical vibrator and symmetrically with respect to the axial center of said electrical vibrator.
9. An atomizing apparatus according to any of claims 1 to 6, further including means for filling the liquid in said cavity.
10. An atomizing apparatus according to claim 9, including means operatively coupled with said filling means for delivering air to carry therewith said atomized droplets expelled out of said orifices.
11. An atomizing apparatus according to claim 10, said filling means being responsive for its operation to an air pressure developed by said air delivering means.

FIG. 2

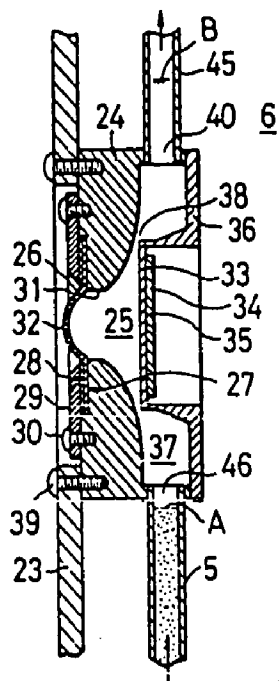


FIG. 3

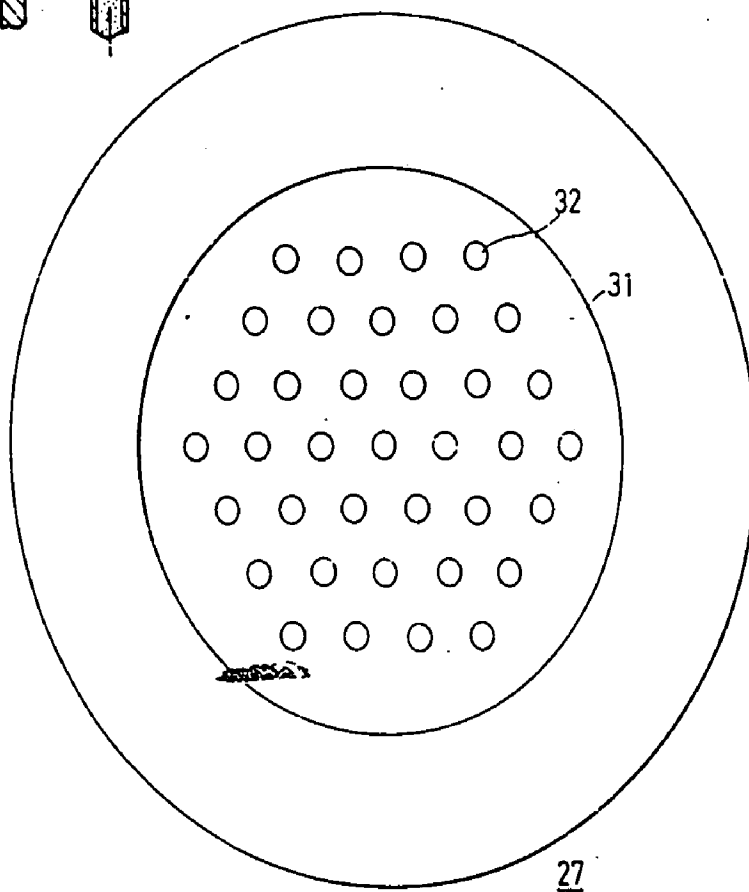


FIG. 4

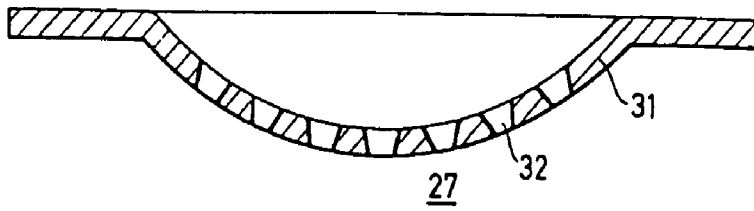


FIG. 5

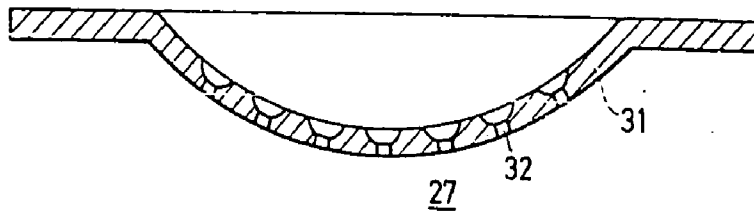


FIG. 7

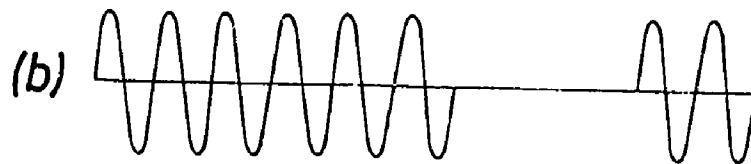
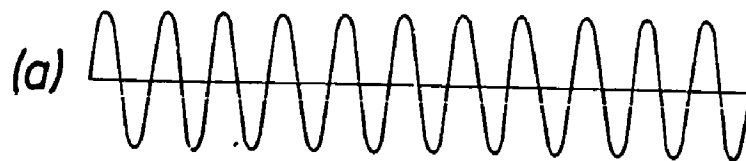


FIG. 6

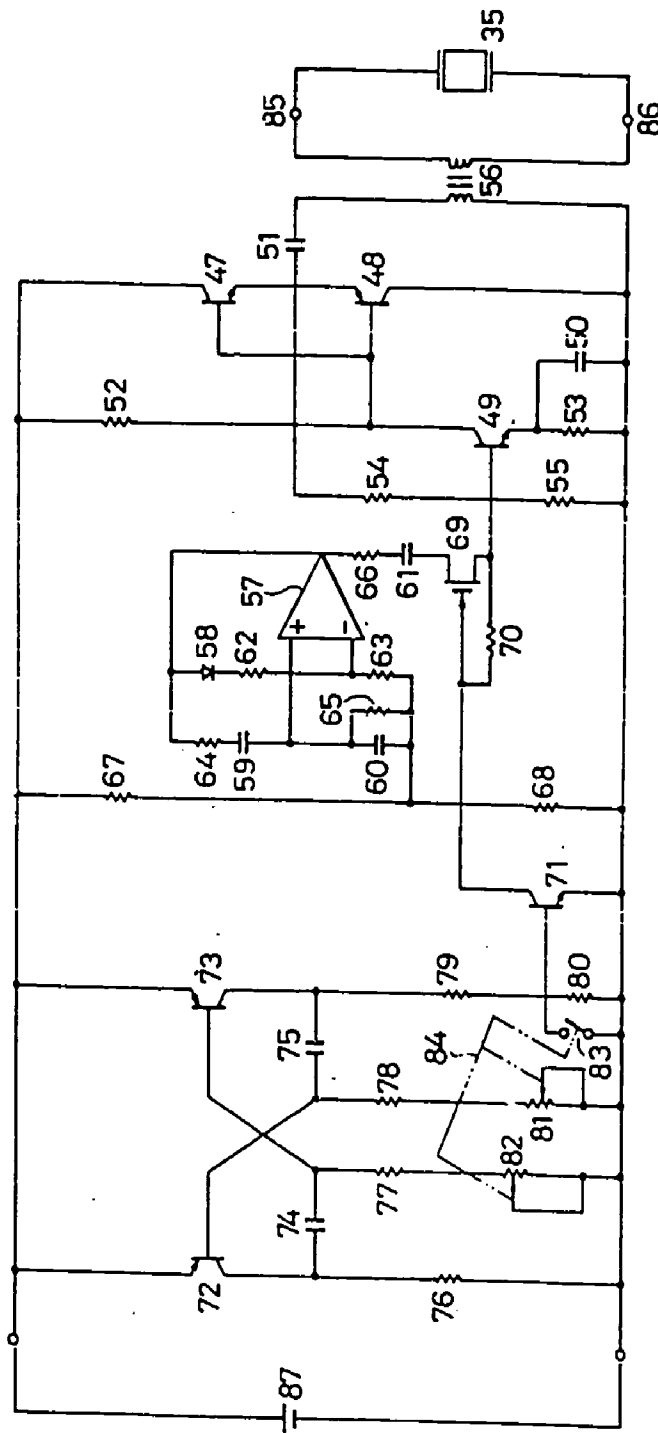




FIG. 8

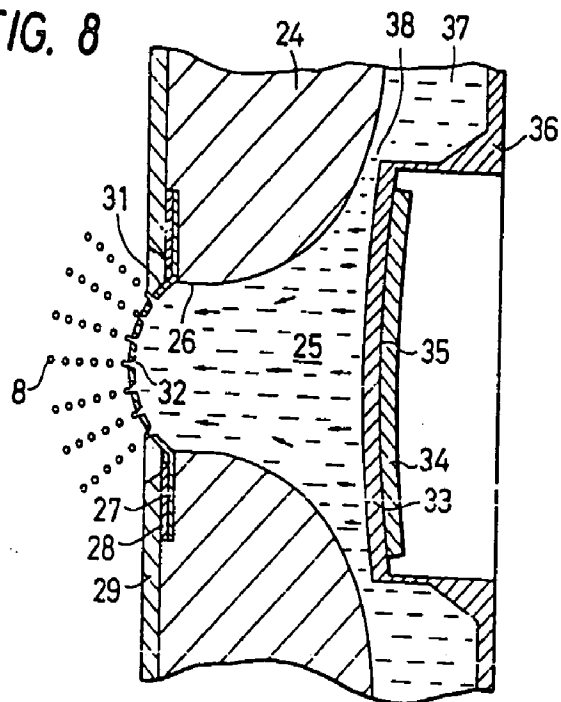


FIG. 9

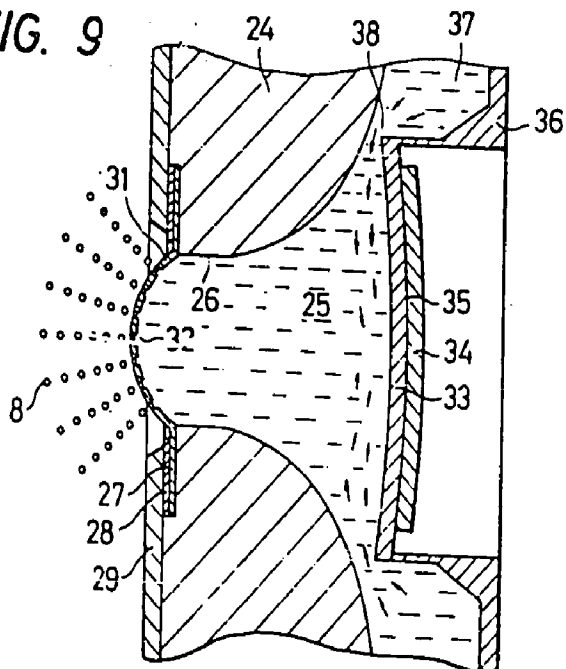


FIG. 10

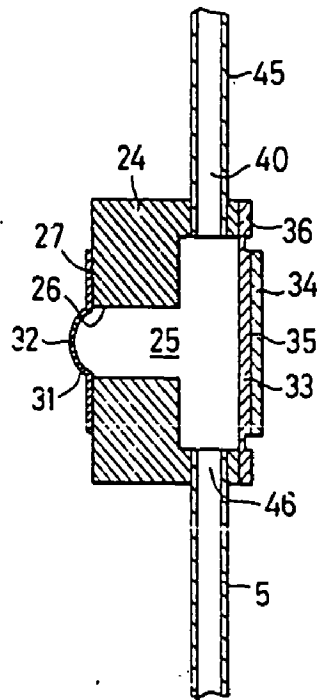


FIG. 11

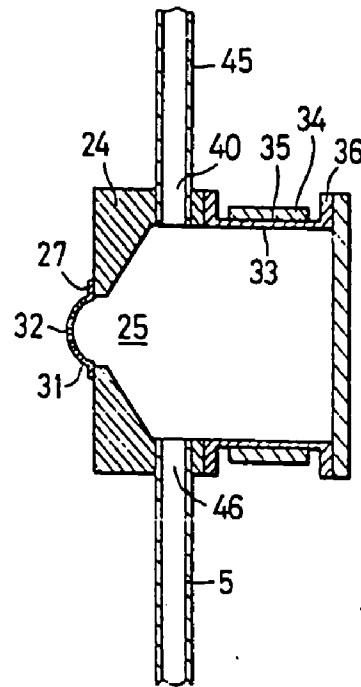


FIG. 12

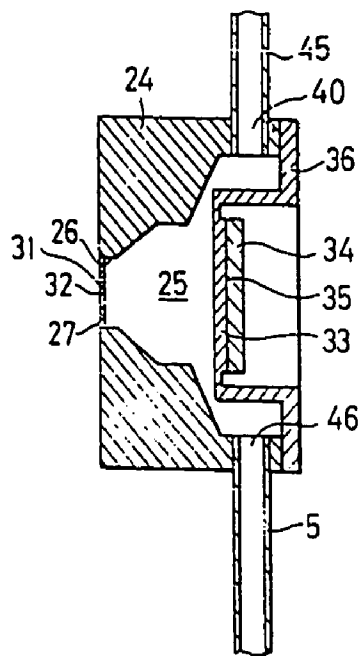
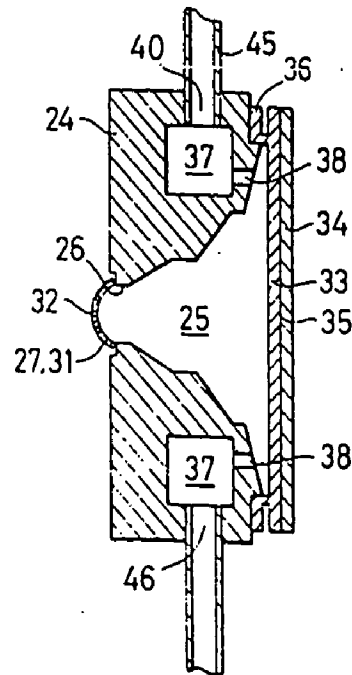


FIG. 13



DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int. Cl. 7)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
X	<p>TRANSACTIONS OF THE ASAE, vol. 17, no. 1, January/February 1974, pages 183-187 Michigan, U.S.A. L.F. BOUSE et al.: "Cyclic disturbance of jets to control spray drop size"</p> <p>" Pages 183, 184 "</p> <p>--</p> <p><u>JP - A - 55 94665</u> (TATEISHI DENKI K.K.)</p> <p>" Abstract "</p> <p>----</p>	<p>1-3, 5, 9</p> <p>4</p>	<p>B 05 B 17/06 F 23 D 11/34</p>
			<p>TECHNICAL FIELDS SEARCHED (Int. Cl. 7)</p>
			<p>B 05 B F 23 D B 41 J</p>
			<p>CATEGORY OF CITED DOCUMENTS</p>
			<p>X: particularly relevant if taken alone Y: particularly relevant if combined with another document of the same category A: technological background C: non-written disclosure P: intermediate document T: theory or principle underlying the invention E: earlier patent document, but published on, or after, the filing date D: document cited in the application L: document cited for other reasons</p>
<p>X The present search report has been drawn up for all claims</p>			<p>&amp;: member of the same patent family. corresponding document</p>
Place of search	Date of completion of the search	Examiner	
The Hague	11-01-1982.	COLPAERT	